B-22: Coastal Landcover Classification Using NASA's Airborne Terrestrial Applications Sensor (ATLAS) Data

C.C. Nichols[1], T.C. Siewicki[1], J.W. Daugomah[1], D.E. Porter[2], B. Jones[2], and J.R. Jensen[3]

NOAA/NOS/Center for Coastal Environmental Health and Biomolecular Research, Charleston, SC, USA [1]
Department of Environmental Health Sciences and Belle W. Baruch Institute, University of South Carolina, Columbia, SC, USA[2]
Department of Geography, University of South Carolina, Columbia, SC, USA [3]

ABSTRACT

Impervious surface is a key indicator of the extent of urbanization within a given geographic area. Extensive impervious surface area can reduce quality of nearby waterways by increasing runoff volume, increasing peak flow rates, and reducing rainwater infiltration and pollutant filtering by subsurface flow (Corbett et al., 1997). Thus, relatively easily attained estimates of impervious surface area would allow both a measure of urbanization and risk to receiving waters. In comparison, vegetated surface area slows runoff and traps pollutants better than open land. Estimates of percent impervious surface, vegetated, and open land, along with morphology of urban land use, where shape and density are key elements, can be measured and analyzed with the use of Remote Sensing and Geographic Information Systems (GIS). NASA's Airborne Terrestrial Applications Sensor (ATLAS) data were used to classify areas of Murrells Inlet, South Carolina into three land-cover classes: impervious surfaces, open land, and vegetation. The spectral range of ATLAS is 0.45 - 12.2 µm and is displayed in 14 channels with a 3 meter (m) Ground Spatial Resolution (GSR). The ATLAS data were rectified, transformed using ENVI's Principal Components Analysis (PCA), classified using a parallelepiped classifier from ERDAS, Inc. Image Analysis extension for Arcview, and converted to vector format for use with the GIS. The accuracy of the classification was estimated using a hybrid approach of ground-truthing and a visual examination of the National Aerial Photography Program's (NAPP) Color Infrared (CIR) aerial photography with a GSR of 1 m. Remotely sensed impervious, vegetated, and open surfaces are being used in empirical relationships to predict risks to and impacts upon the receiving estuary.

INTRODUCTION

Objectives:

(1) To develop a three class (impervious, vegetated, open) landcover classification of Murrells Inlet that will assist in quantifying the effects of urbanization on the estuarine ecosystem
(2) To calculate the percent impervious, vegetated, and open surface in the upland surrounding the Murrells Inlet estuary

Definition of three classes

(1) Impervious surface - concrete, roads, and rooftops
(2) Vegetation - coniferous and non-coniferous
(3) Open areas - open fields, pastures, highway medians, and grass lawns

METHODS

Two 14-channel ATLAS (Table I) images (a coastal and an inland image are displayed together in Figure 1) were used to classify the Murrells Inlet upland. These images were acquired on 7 October 1997 at 16:44 to 17:06 GMT at an altitude of 5000 feet (ft) (1524 meters (m)) with a GSR of 3 m. These data were registered, transformed, classified, assessed for classification accuracy (Figure 2).

Table I. System Specifications of the NASA Airborne Terrestrial Applications Sensor (ATLAS)

SPECTRAL			
Spectral Range	0.45 - 12.2 µm		
# of Channels	14		
	Channel	**Radiometric Sensitivity**	**SNR***
Spectral Coverage	Ch. 1: 0.45-0.52 µm	0.034	89
	Ch. 2: 0.52-0.60 µm	0.036	261
	Ch. 3: 0.60-0.63 µm	0.027	179
	Ch. 4: 0.63-0.69 µm	0.032	419
	Ch. 5: 0.69-0.76 µm	0.037	488
	Ch. 6: 0.76-0.90 µm	0.035	369
	Ch. 7: 1.55-1.75 µm	0.037	45
	Ch. 8: 2.08-2.35 µm	0.026	84
	Ch. 9: Removed	-	-
	Ch. 10: 8.20 – 8.60 µm	0.123	162
	Ch. 11: 8.60 – 9.0 µm	0.128	156
	Ch. 12: 9.0 – 9.4 µm	0.143	140
	Ch. 13: 9.6 – 10.2 µm	0.099	202
	Ch. 14: 10.2 – 11.2 µm	0.132	151
	Ch. 15: 11.2 – 12.2 µm	0.335	60
SPATIAL			
Field of View (FOV)	72°		
Instantaneous Field of View (IFOV)	2.0 mrads		
Pixels/Lines	640 ground scene plus 3 calibration source pixels		
Scan Speed	6-50 scans per second		
Ground Spatial Resolution	3.0 m		

* Signal to Noise Ratio (SNR) measurements using a 4° integrating sphere spectral radiance calibration curve; NIST T in °C for the thermal channels.

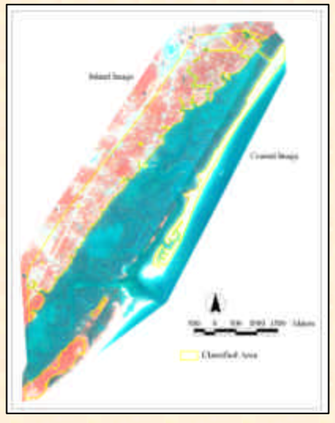

Figure 1. Murrells Inlet coastal and inland ATLAS scenes, displaying band 15

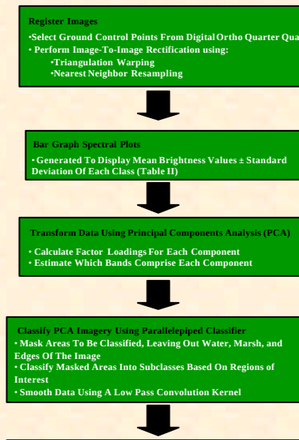

Figure 2. Methods used

Table II. Bar Graph Spectral Plot of Landcover Types showing separation of Impervious surface and vegetation in the Thermal Infrared range (channels 10-15).

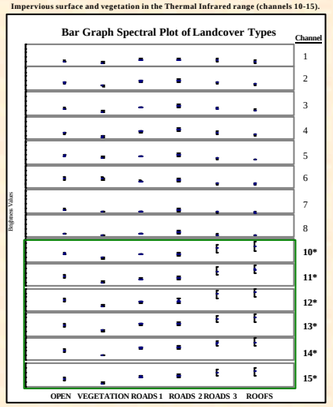

Table III. Accuracy assessment

	Coastal	Inland
Overall Accuracy	90%	91%
Producer's Accuracy (omission error)		
Impervious	86 % (14 %)	94 % (6 %)
Vegetation	100 % (0 %)	92 % (8 %)
Open Land	84 % (16 %)	88 % (12 %)
User's Accuracy (commission error)		
Impervious	86 % (14 %)	94 % (6 %)
Vegetation	102 % (0 %)	90 % (10 %)
Open Land	86 % (14 %)	90 % (10 %)
Khat	85%	87%

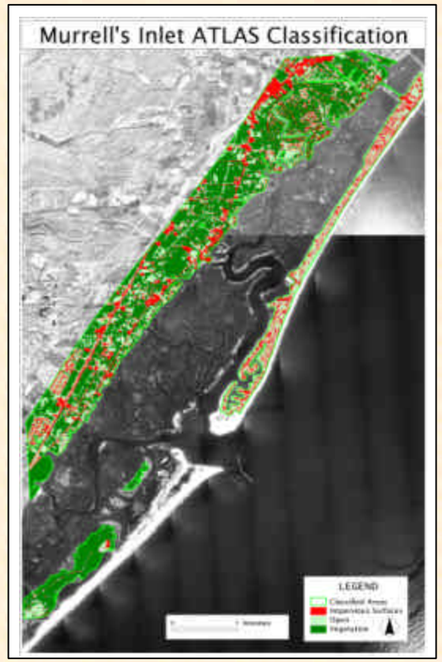

Figure 3. Murrells Inlet ATLAS landcover classification displayed on a 1994 NAPP CIR.

Figure 4. Circular buffers and thiessen polygons of sample sites and critical line buffers in Murrells Inlet, SC. These parameters were constructed with the aid of GIS to quantify urban impacts on the estuarine system.

RESULTS AND DISCUSSION

We estimated total upland impervious surface in Murrells Inlet, SC at 24 - 27 %. This compares to significant impacts on water quality in adjacent estuaries for landscapes (ecosystems) with 30 - 35 % impervious surface (Arnold and Gibbons, 1996; Lerberg, 1997). Higher levels of impervious surface near riparian margins cause increased movement of chemical and microbial contaminants into the estuary (Arnold and Gibbons, 1996). Studies are underway at our laboratory and others to quantify the relationship between location and extent of impervious surface and impacts on the overall health of the estuary by using circular buffers, wetland buffers, and thiessien polygons of sample sites (Figure 4).

Vegetated land cover reduces storm water runoff by depleting soil water, improving infiltration through root pores and increasing surface roughness (Ward and Elliot, 1995). Figure 2 shows reduced upland vegetation near riparian margins where effects on runoff are greatest (Peterjohn and Correll, 1984). Protection of vegetation by use of setbacks and buffers may maintain estuarine water quality in future developments; although, these management tools will be limited in already developed areas like Murrells Inlet.

Our overall classification accuracy and RMS error for both images were about 90 % and 30 m, respectively (Table III). Individual land cover class accuracies ranged from 86-100 % (Table III). The classification could be improved by coupling the two images. Also, PCA could be conducted on visible, near infrared, middle infrared, and thermal infrared bands separately, then the individual components could be combined. In addition, the development of Yang's (1997) generalized multisurface kernel rectification for ATLAS data would improve the geometric integrity of the imagery (Schill, personal communication) as well as a continuous piecewise geometric rectification suggested by Minhe (2000).

We are developing empirical relationships, i.e., statistical models, of easily measured land use/land cover, water, and sediment quality parameters of risk related to habitat changes and contamination. User-friendly means of estimating impervious and vegetated surfaces will be employed to improve existing models of risks to estuarine organisms. These models are provided to natural resource managers and developers to test alternative approaches and to minimize effects of urbanization on estuarine functionality.

ACKNOWLEDGEMENTS

This work was supported by the NOAA Coastal Ocean Program Urbanization and Southeastern Estuarine Systems (USES) Project, and the National Aeronautics and Space Administration's (NASA's) Experimental Program to Stimulate Competitive Research (EPSCoR).

REFERENCES

C.L. Arnold and C.J. Gibbons. "Impervious Surface Coverage: the Emergence of a Key Environmental Indicator," Journal of the American Planning Association, Vol. 62, No. 2,pp 243-259, 1996.

C. Corbett M. Wahl, D. Porter, D. Edwards, and C. Moise, "Nonpoint Source Runoff Modeling a Comparison of a Forested Watershed and an Urban Watershed on the South Carolina Coast," Journal of Experimental Marine Biology and Ecology, Vol. 213,pp 133-149, 1997.

J. Dobson , E. Bright, R. Ferguson, D. Field, L. Wood, K. Haddad , H. Iredale, J. Jensen, V.Klemas, R. Orth, J. Thomas, "NOAA Coastal Change Analysis Program (C-CAP). Guidance for Regional Implementation," NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995, Revised November 1999.

J. Jensen, *Introductory Digital Image Processing: A Remote Sensing Perspective*, Prentice Hall, Upper Saddle River, New Jersey, 1996.

S.B. Lerberg , *Effects of Watershed Development on Macrobenthic Communities in the Tidal Creeks of the Charleston Harbor Estuary*, Masters Thesis, Graduate Program in Marine Biology, University of Charlestos, Charleston, 257 pp, 1997.

D.L. Light, "The National Aerial Photography Program as a Geographic Information System Resource," Photogrammetric Engineering and Remote Sensing, Vol 59, No. 1,pp 61-65, 1993.

T. Lillesand and R. Kiefer, *Remote Sensing and Image Interpretation* , John Wiley and Sons, Inc., New York, 1994.

J. Minhe and J.R. Jensen, "Continuous Piecewise Geometric Rectification for Airborne Multispectral Scanner Imagery," Photogrammetric Engineering and Remote Sensing,Vol. 66, No. 2, pp. 163-171, 2000.

W.T. Peterjohn and D.L. Correll, "Nutrient dynamics in an Agricultural Watershed: Observations on the Role of a Riparian Forest," Ecology, Vol 65, pp 1466-1475, 1984.

S. Schill, Project Manager, NASA Affiliated Research Center, Personal Communication, 1999.

T. Schueler, "The Importance of Imperviousness," Watershed Protection Techniques, Vol . 1, No. 3, pp. 37-48, Fall 1994.

A. Ward, and W. J. Elliot, *Environmental Hydrology*, Lew Publishers, New York, NY, 1995.

X. Yang, *Georeferencing Calibrated Airborne Multispectral Scanner (CAMS): Polynomial Rectification and Beyond* Ph.D. Dissertation, Department of Geography, University of South Carolina, Columbia, 325 pp., 1997.